

Does Future Home Networking Look Blue?

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The home is the last bastille for networking. The reasons are as varied as the homes and the people who live within them. Determining what must be, should be, or might be networked and how this may be accomplished is the subject of this paper.

Some people call it home networking, others call it pervasive computing, but no matter how one looks at it, it means that new technology is applied where it did not exist before. The home contains many individual devices. The connecting of these devices via wires or wireless means for some is already under way. The pace at which these and the other devices will be connected will depend on the cost of the new technology, the marketing by manufacturers, and the acceptance by the consumers.

The challenges to home networking are determining what devices to network and which networking technology or technologies to use. The first part of this paper provides some answers to the first question of what to network by listing potential devices in the home that may be networked and the benefit for networking them. The second part provides some answers to the second question of selecting a networking technology. Three potential home networking technologies are examined. The three networking technologies examined are Home Phoneline Networking Alliance (HomePNA) version 2.0, Home Radio Frequency (HomeRF) version 2.0, and the Bluetooth™ wireless technology versions 1.0B and 1.1. HomePNA is a wired solution designed to work on current power and phone lines. HomeRF and Bluetooth are wireless solutions. HomeRF uses a combination of IEEE 802.11 and DECT technologies to achieve both reserved and free time/space for data transport. The Bluetooth wireless technology is a complete Open Systems Interconnection (OSI) stack of protocols and specifically designed profiles to implement certain applications.

Emphasis is placed on the Bluetooth wireless technology. Protocols, mainly those for networking (the core), will be examined. Some performance data is presented based on experiments conducted with a set of Bluetooth development kits and some sample home networking environments.

The applicability of the examined home networking technologies to the suggested home devices is the conclusion of the paper.

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Information Technology Laboratory

Devices in the home

- Anything that runs on electricity
 - Obvious
 - telephones
 - personal computer(s)
 - televisions
 - VCR
 - CD- & DVD-players
 - stereo/radio
 - security system & sensors
 - Not-so obvious
 - door bell
 - clocks
 - garage door
 - lights
 - heating & air conditioning
 - washer/dryer
 - kitchen appliances

Why connect devices in the home

- Cable replacement
- Lack of access
- Movement
- Centralize control (remote control)
- Sharing data
- New services or functions

What devices to connect in the home

- Hand set to Cradle
- Cradle to Access Point
- Keyboard, Mouse, Monitor, Printer, etc. to Personal Computer
- PC to PC
- Televisions to remote or signal receiver (i.e. antenna, cable, satellite)
- Clocks
- On/Off button to bell, lights, garage door, etc.
- Alarms or indications to single point (i.e. human or control panel)
- CD- & DVD-players and stereo/radio to remotes, head sets, and speakers

How to connect devices in the home

- Cables (Coax, Twisted pair, other)
- Telephone wiring (HomePNA)
- Wireless (HomeRF & Bluetooth)

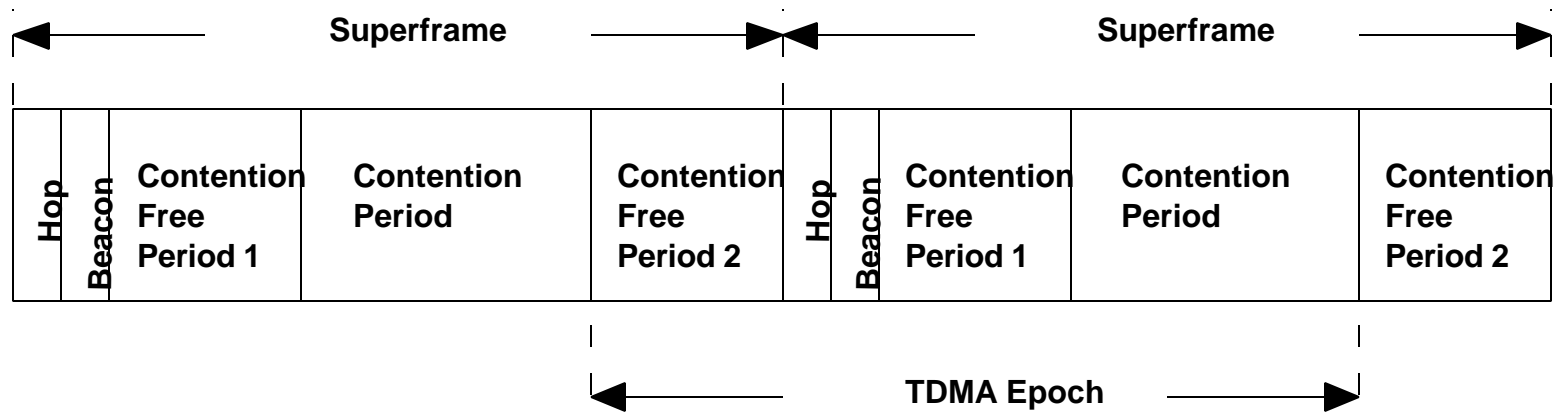
HomePNA

- HomePNA 1.0
 - Data rate
 - 1 Mbit/s
 - Over existing phone wires
- HomePNA 2.0
 - Data rate
 - 10 Mbit/s
 - Over existing phone wires

HomeRF

- SWAP 1.0 (\$500.00)
 - Multiplexing scheme
 - TDMA &
 - CDMA/CA
 - Data rates
 - 0.8 Mbit/s
 - 1.6 Mbit/s
 - Voice
 - 32 K ADPCM
 - 4 connections
 - Distance
 - 100 meters
- SWAP 2.0 (\$2500.00)
 - Multiplexing schemes
 - TDMA,
 - CDMA/CA, &
 - Priority CDMA
 - Data rates
 - 5 Mbit/s
 - 10 Mbit/s
 - Voice
 - 32 K ADPCM
 - 8 connections

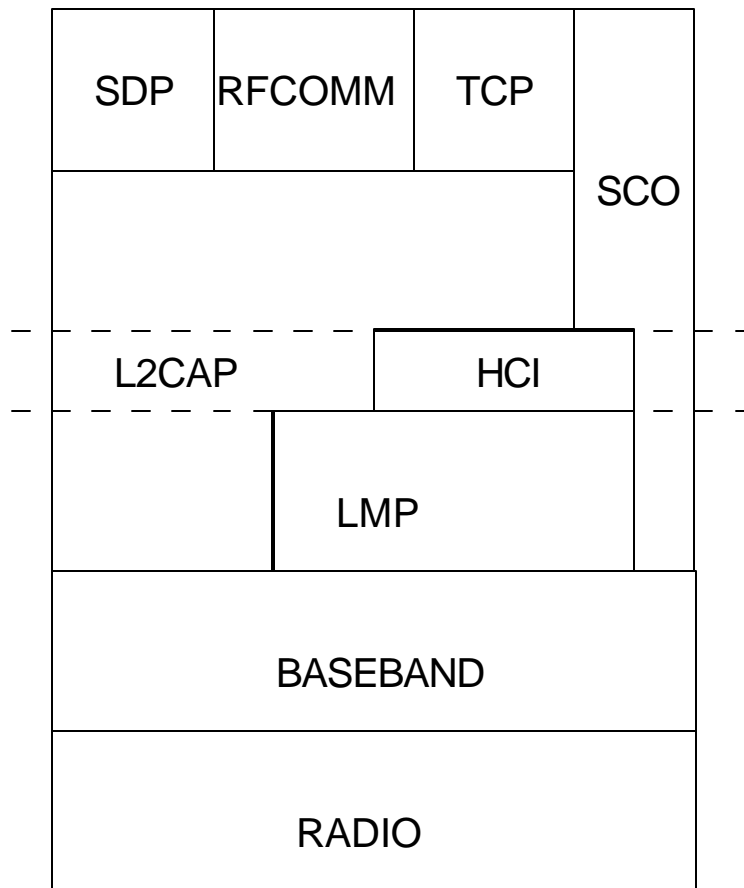
HomeRF



Bluetooth

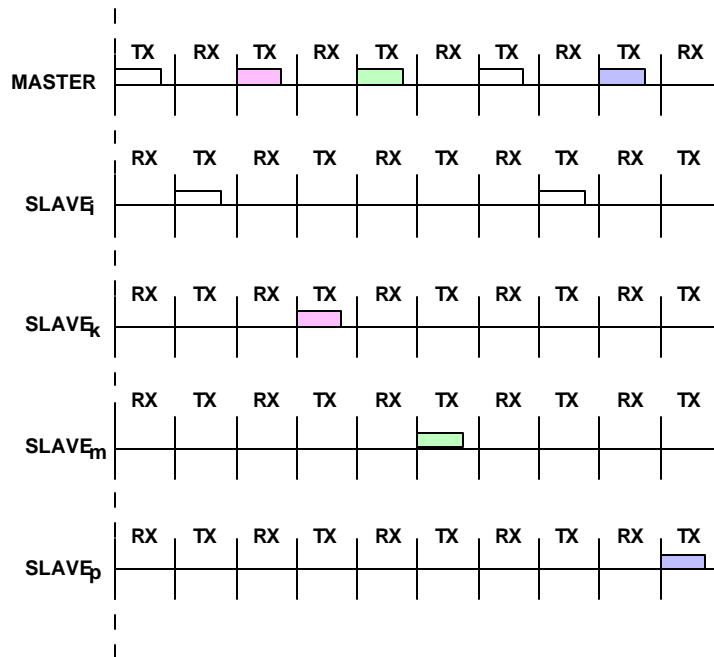
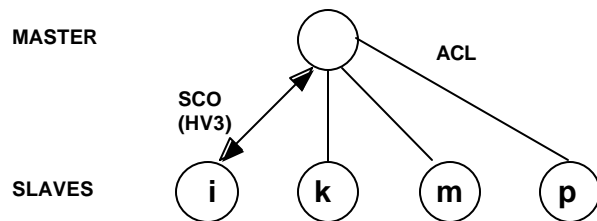
- Core 1.0, 1.0A, 1.0B, & 1.1 (free)
 - Multiplexing scheme
 - TDMA
 - Data Rate
 - 433.9 kbit/s max symmetric
 - 723.2 kbit/s max asymmetric
 - Voice
 - 64 kbit/s
 - 1,2, or 3 connections
- Distance
 - 10 meters

Bluetooth protocols (core)



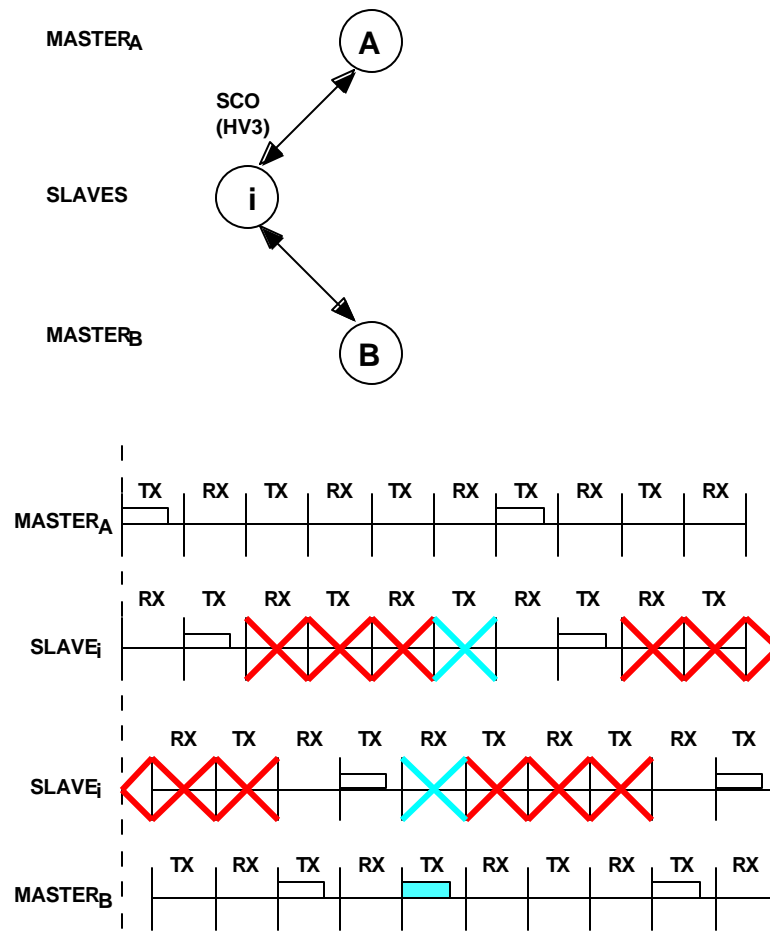
- Radio
- Baseband
- Link Manager Protocol (LMP)
- Logical Link Control and Adaptation Protocol (L2CAP)
- Host Control Interface (HCI)
- Service Discovery Protocol (SDP)
- RFCOMM
- IrDA Interoperability
- Telephony Control Protocol (TCP)
- Test Mode

Bluetooth (piconet)



- Piconet
 - ACL
 - (1 Master & 1-7 Slaves)
 - SCO
 - (1 Master & 1-3 Slaves)
 - Mixed
 - (1 Master & 1-* Slaves)

Bluetooth (scatternet)



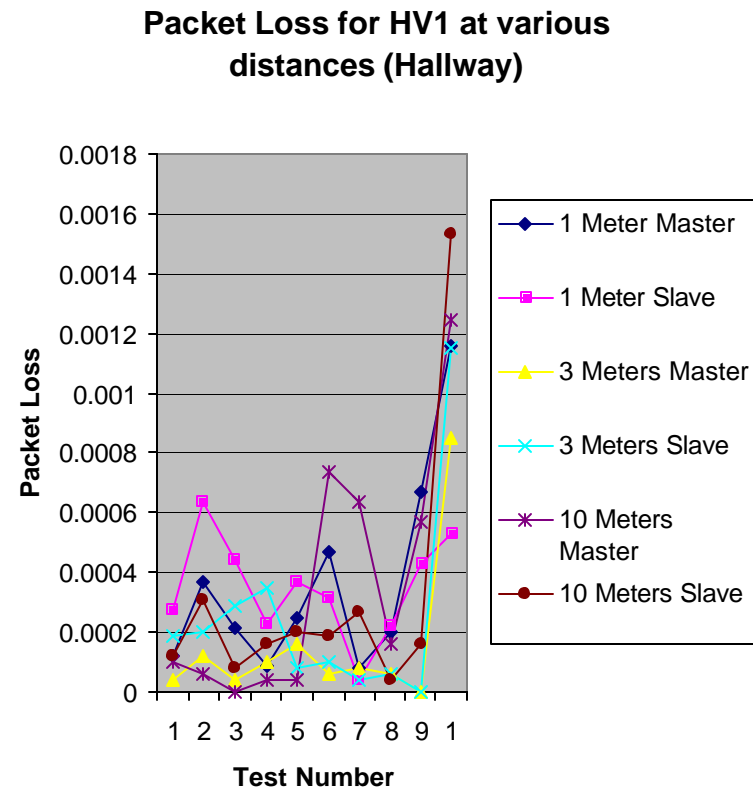
- Scatternet
 - ACL
 - (2 Masters & ????)
 - SCO
 - (2 Masters & 1 Slave using HV3)

Performance tests

- Various Baseband packet types used
- 1, 3, and 10 meter distances used
- Developers' kit used
- Various environments used

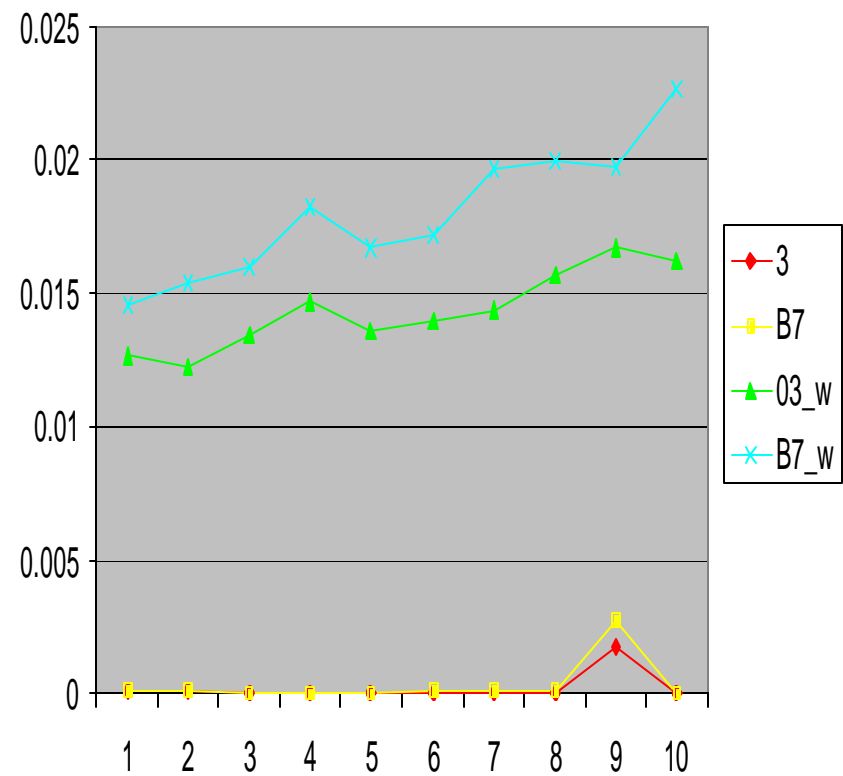
Performance data (hallway)

- No significant difference whether Master or Slave
- 3 meter distance appears to have lowest average packet loss
- No significant Packet loss difference as distances change



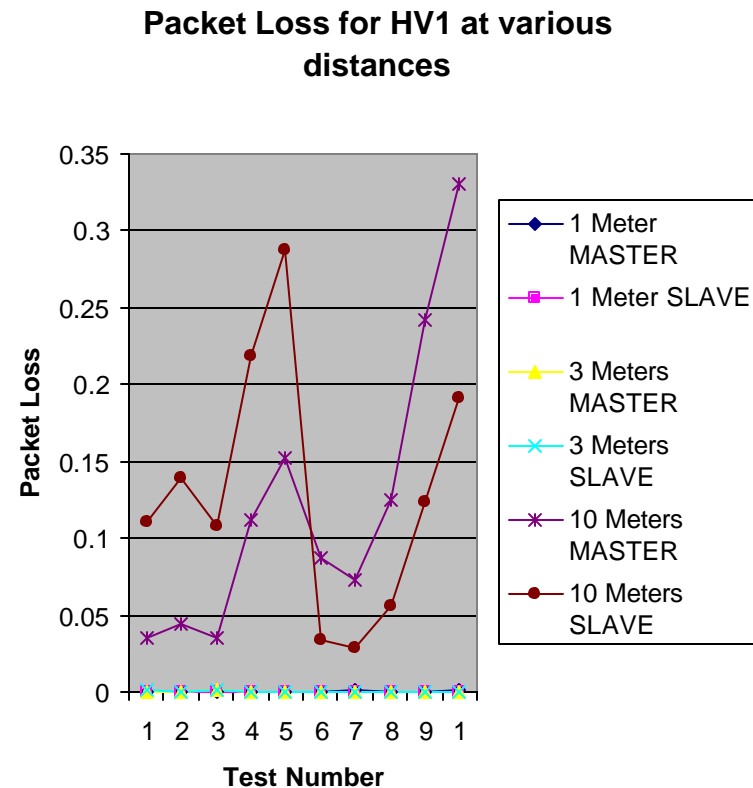
Performance data (with microwave)

- Significant impact at only 1 meter distance between Master and Slave devices



Performance data (country)

- Could not reach 10 meters, only 8.36 meters
- Significant error differences with change in distance



Applicability of technologies to home devices

Technology Why	HomePNA	HomeRF	Bluetooth
Cable replacement	No	Yes*	Yes
Lack of access	No	Yes	Yes
Movement	No	Yes	Yes
Centralized control	Yes	Yes	Yes
Sharing data	Yes	Yes	Yes
New services or functions	Yes	Yes	No*

Applicability of technologies to home devices

Technology Devices	HomePNA	HomeRF	Bluetooth
Hand set to Cradle	N/A	Yes*	Yes
Cradle to access point	N/A	Yes*	Yes
Keyboard, Mouse, Printer, etc. to PC	Yes*	Yes*	Yes
PC to PC	Yes	Yes	Yes
Television to remote or signal receiver	No	No	Yes*

Applicability of technologies to home devices

Technology Devices	HomePNA	HomeRF	Bluetooth
On/Off button to bell, lights, garage door, etc.	N/A	Yes*	Yes
Alarms or indications to single point	N/A	Yes*	Yes
CD- & DVD-players and stereo/radio to remotes, head sets, and speakers	Yes*	Yes*	Yes
Clocks	Yes*	Yes*	Yes*